Energy Policy 118 (2018) 33–40

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Policy impact of new energy vehicles promotion on air quality in Chinese cities

Ruipeng Tan[a], Di Tang[b], Boqiang Lin[c,*]

[a] China Center for Energy Economics Research, the School of Economics, Xiamen University, Xiamen, Fujian 361005, PR China
[b] International Business China AMC, Beijing 100000, PR China
[c] School of Management, China Institute for Studies in Energy Policy, Collaborative Innovation Center for Energy Economics and Energy Policy, Xiamen University, Fujian 361005, PR China

ARTICLE INFO

Keywords:
"Ten Cities, Ten Thousand NEVs project"
"Difference-in-differences" method
Urban air nitrogen dioxide concentration
Chinese cities

ABSTRACT

We conduct a rigorous and systematic empirical study on the effect of "Ten Cities, Ten Thousand New Energy Vehicles (NEVs) project" on urban air quality. After examining the applicable conditions of the "difference-in-differences" method, we demonstrate that this project meets the parallel trend assumptions, randomness assumptions and homogeneity hypothesis in terms of the impact on air quality, represented by urban air nitrogen dioxide concentration. Thus, during the whole promotion period, the promotion of new energy vehicles can reduce the concentration of nitrogen dioxide in urban air, but the effect is not significant every year of the promotion. The effect of the project evolves over time. The fact that the effect of reducing the concentration of urban air nitrogen dioxide is small is relevant to the small number of new energy vehicles, because the entire project did not attain the expected target. As a result, the promotion of new energy vehicles has become an option to improve urban air quality, especially by reducing air nitrogen dioxide concentration.

1. Introduction

The great achievement of China's economic advancement is made at the expense of the environment. The use of coal-based fossil fuels emitted large greenhouse gases (mainly carbon dioxide) and polluting gases. China's urbanization process has accelerated in recent years, causing urban traffic congestion, automobile exhaust and industrial emissions, and resulting in serious decline in environmental quality (Yang et al.,2018). Seven of world's top ten air pollution cities in 2003 are in China. Less than 1% of the whole Chinese cities meet the WHO (World Health Organization) air quality standards. According to *2016 China's Environmental Status Bulletin*, only 84 cities meet the ambient air quality standards, accounting for only 24.9% of the total number of cities; the air quality in the rest 254 cities is unqualified. 474 cities (districts and counties) conducted precipitation monitoring, and the results show that the pH value of annual rainfall is less than or equal to 5.6 in about 19.8% of the cities, and the average acid rain frequency is 12.7%.

Automobile exhaust has become an important source of urban air pollution (Sun et al., 2018). According to a United Nations (UN) report, automobile exhaust emissions accounted for more than 60% of all the substances in air pollution in cities. The harmful substances in automobile exhaust include: solid suspended particulates, carbon monoxide, nitrogen oxides and so on. Nitrogen oxides can do great harm to the environment and human's health (Dhondt et al., 2012). Nitta et al. (1993) and Sekine et al. (2004) provided evidence that exposure to heavy traffic was related to increased risk of respiratory symptoms, with higher concentration of nitrogen dioxide being one of the causes. Apart from its direct effect on human health, it can react with other substances to produce acid rain, and corrode materials and affects the normal growth of plants. The nitrogen oxides and hydrocarbons may even react to produce photochemical smog that has caused casualties in Tokyo and Los Angles (Lin and Tan, 2017a). Worse still, nitrogen oxides play an indispensable role in the formation of PM2.5 (particulate matter with diameter less than or equal to 2.5 µm), which is the most important factor causing haze (Lin and Tan, 2017b).[1]

The concentration of nitrogen is greatly influenced by human activities and decreased during the period 2010–2015, reflecting that China's air pollution control policy has worked in recent years, especially technical and administrative policies aimed at controlling automobile exhaust emissions (Sun et al., 2016). For example, installing a catalytic reactor in the exhaust system of a vehicle, by which the carbon

* Corresponding author.
E-mail addresses: bqlin2004@vip.sina.com, bqlin@xmu.edu.cn (B. Lin).

[1] Since there is no data on concentration of carbon monoxide, PM2.5 and PM10 (particulate matter with diameter less than or equal to 10 µm) for some sample cities in this research, we take the concentration of nitrogen oxides as the representative of city air quality in this paper.

https://doi.org/10.1016/j.enpol.2018.03.018
Received 19 September 2017; Received in revised form 22 January 2018; Accepted 6 March 2018
0301-4215/

monoxide can be oxidized to carbon dioxide using a catalyst, and the nitrogen oxides can be reduced to nitrogen; or adding additives to the fuel to make it burn efficiently. The administrative measures include improving the quality of the refined oil, eliminating old cars, promoting the use of public transport and so on.

Different from traditional fossil energy vehicles, new energy vehicles are driven by unconventional energy and have become one of the most important tools to reduce automobile exhaust emissions. Both the Chinese central government and local governments have adopted a series of policies to promote the use of new energy vehicles since 2009. The current types of new energy vehicles include pure electric, plug-in hybrid and fuel cell vehicles.

As the first important attempt to promote the use of new energy vehicles, China's Ministry of Science and Technology, the Ministry of Finance, National Development and Reform Commission, Ministry of Industry and Information jointly launched the “Project of promoting the application of large-scale new energy vehicles”, which is also called "Ten Cities, Ten Thousand New Energy Vehicles Project” (hereinafter referred to as “Ten Cities, Ten Thousand NEVs Project”) in 2009. The government plans to use financial subsidies and other measures to pilot the use of new energy vehicles in thirty cities within three years, and seeks to make new energy vehicles account for 10% of the automobile market by the end of 2012. The extension coverage includes buses, taxis, official, municipal and postal services. Because new energy vehicles are mainly fueled by electricity, their emissions can be seen as zero in the urban districts. In this way, their effects on air quality is an important and significant empirical economic issue. However, most of the existing literature on new energy vehicles in China is concentrated on the development of the new energy vehicle industry themselves, ignoring other aspects. Although the original intention of developing new energy vehicles in China is not to control air pollution, the new energy vehicles will affect air quality undoubtedly because of their cleanness. In this paper, we attempt to investigate the impact of the policy on air quality. This kind of empirical research can quantitatively measure the extent of the impact of new energy vehicles on urban air quality and evaluate the policy of promoting new energy vehicles. These are the contributions of this research to the literature. We use the case study of the “Ten Cities, Ten Thousand NEVs Project” for the analysis.

We only analyze the nitrogen dioxide concentration because of the following reasons. First, the research period of this study is from 2005 to 2012 in which the data on Air Pollution Index (API) and Air Quality Index (AQI) are unavailable (the former is released from 2006 to 2012 and the latter is released from January 2013). Second, both API and AQI are available only for the major cities in China. That is, for some cities in our study, the API data is unavailable even from 2006 to 2012. Third, data on the concentrations of other automobile exhaust pollutants such as carbon monoxide are not released before 2013. Fortunately, data on nitrogen dioxide concentration can be obtained for the period 2005–2012 for all the cities in this study. Fourth, nitrogen dioxide is the main exhaust of vehicles. Fifth, there is no statistical data on CO_2, which is from transport energy use (Mi et al., 2017b) on Chinese city level, for each type of energy consumption of each city is unavailable. It is therefore difficult to calculate the CO_2 emissions by multiplying the amount of energy and the corresponding emission coefficient. Another way is to obtain the CO_2 emissions data by GIS spatial analysis, and the data resource is CHRED (Cai and Zhang, 2014). However, it has only released the data of two years: 2007 and 2012. Therefore, CO_2 is not used as a proxy of air quality in this paper.

The rest of this paper is organized like this: the second part is the literature review which summarizes the studies on new energy vehicles. The third part shows how we conduct the analysis. The fourth part presents the empirical results and the testing on the method suitability. The last part is the robustness check and main conclusions.

2. Literature review

As the future development direction of the automotive industry, new energy vehicles are regarded as key to guaranteeing a country's energy security, protecting the environment and promoting sustainable development. The existing research on new energy vehicles can be roughly divided into two categories. The first is from the aspect of technology. In the assembling of new energy vehicles, the most important parts are energy storage device and battery management system. The currently used energy storage device includes lithium-ion batteries, nickel-metal hydride batteries, lead-acid batteries, zinc air batteries, super capacitors and so on, among which only nickel-metal hydride batteries and lead-acid batteries are in the matured stage, and are widely used in hybrid electric passenger cars, pure electric passenger cars and pure electric commercial vehicles. The other types of energy storage devices are still in the initial stage or development stage (Yuan et al., 2015). However, there are some shortcomings in lithium-ion batteries and nickel-metal hydride batteries that have constrained their portable application (Rao and Wang, 2011). Besides energy storage devices, the battery management system in new energy vehicles is also important. It has two main functions: one is to monitor the battery including its status, discharge capacity, etc. (Ling et al., 2014), and the other is to ensure that the battery is working in safe and effective conditions. Good battery management system can improve the efficiency of the battery and help to extend the service life of the battery (Danilov and Notten, 2009; Škugor and Deur, 2015; Cordoba-arenas et al., 2014).

The second type of research is focused on their impacts on the economy, environment and the grid. Most of the literature on the economic impact focus on the economic viability of electric vehicle to grid (V2G) technology in different markets. The annual profit ranged from \$100 to \$300 (Tomić and Kempton, 2007). Smart charging was found to reduce system costs and were estimated to be €277 per year in the Danish market (Kiviluoma and Meibom, 2011). As a mobile energy storage device, the use of new energy vehicles will also affect the performance, efficiency and capacity of the grid. This impact is mainly affected by the type of new energy vehicles, charging methods, charging time and charging characteristics (Gao and Zhang, 2011). If they are charged during the non-peak load periods, the grid costs will be reduced (Andwari et al., 2017). Juul and Meibom (2011) found that if smart charging method is used, the use of new energy vehicles would increase the efficiency of the grid base load, having a favorable impact on the grid. However, if simple charging strategy is adopted, the peak load would increase. In addition, the development of new energy vehicles can increase the share of photovoltaic and wind power (Bellekom et al., 2012). Turton and Moura (2008) measured the installed capacity of global wind power from 2000 to 2100 under the background of new energy vehicles development and the adoption of electric vehicle to grid technology. They found that the installed global wind power capacity will increase by 30% − 75% by 2100. The centralized photovoltaic is similar to wind power, but distributed photovoltaic can greatly improve the future charging methods of new energy vehicles. Some researchers estimated the areas of required solar panels which can ensure the daily mileage of a plug-in hybrid car. They concluded that in mid-July, a 20-square-meter solar panel would provide the needed energy for a 40-mile trip and 78 m^2 were needed in December to ensure the same mileage (Li et al., 2009).

The impact of new energy vehicles on the environment in the current study is mainly through the measurement of carbon dioxide emissions. In the process, new energy vehicles emit less carbon dioxide, but their production consumes electricity and emits large amounts of carbon dioxide, especially for a country like China, where coal accounted for 49% of the power generation structure (Gu et al., 2010). In terms of this study, different researchers have reached different conclusions. Hofmann et al. (2016) demonstrated that using electric vehicles to substitute petrol vehicles would not reduce carbon dioxide